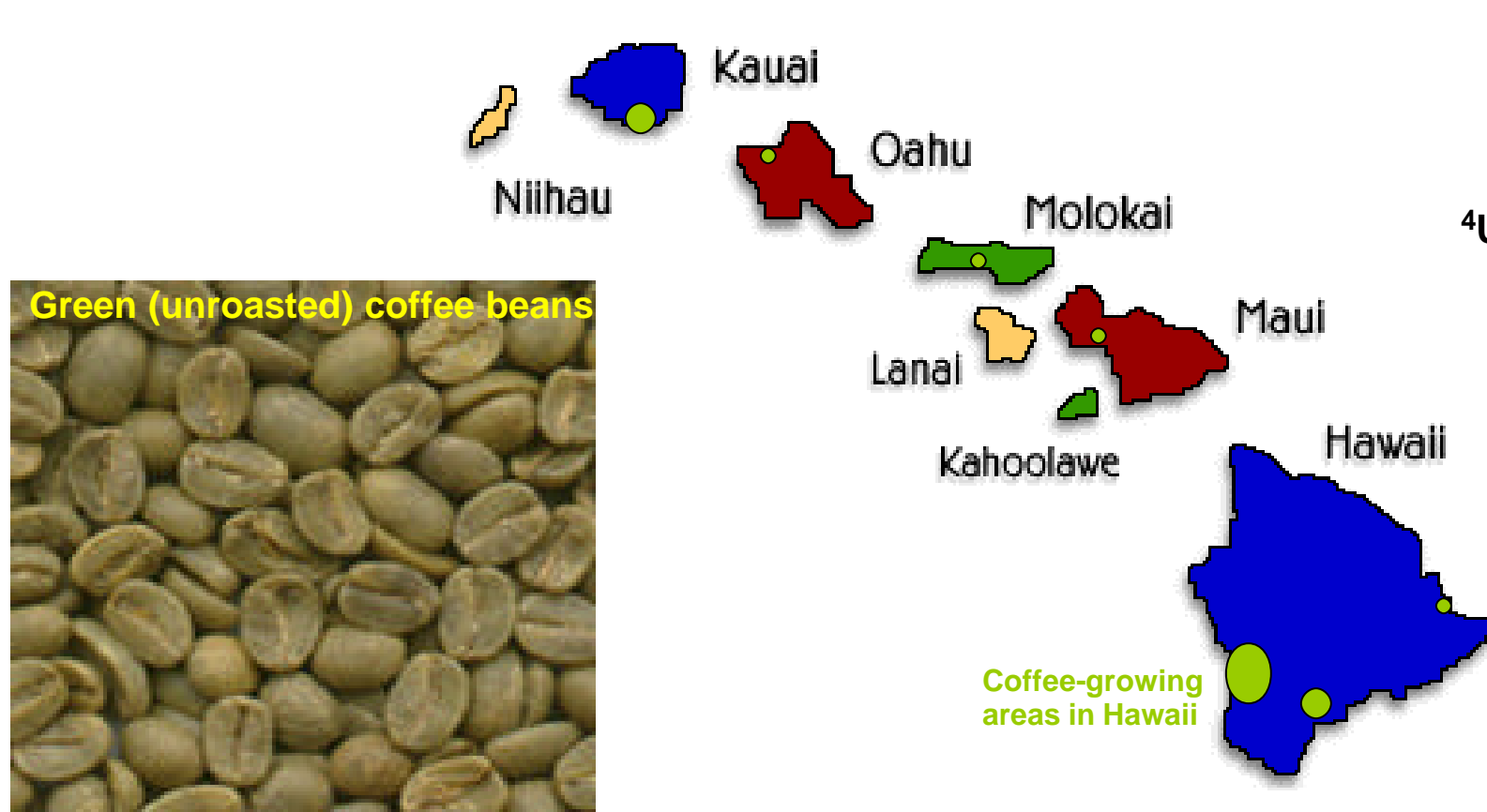


Ozone (O₃) Vacuum Fumigation: A Potential Organic Alternative to Methyl Bromide Fumigation for Green Coffee Berries imported into Hawaii

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RESULTS

Cupping Tests

➤ Results of preliminary cupping tests with Hawaii-grown coffee in six comparison tests were 9/19, 12/19, 7/19, 10/21, 5/21, and 8/21 correct identifications of the O₃-fumigated coffee in tests 1 through 6, respectively. With the exception of test 2 (Significant, $P = .01$), there were no significant differences between the controls and the O₃-treated coffee. The results indicated that O₃ was a potential alternative to MB and further tests were initiated.

➤ Results of cupping tests with green coffee representing a range of coffee varieties are shown in Tables 1 and 2.

Table 1. SAS PROC GLM for control versus treatment cupping test results with three coffee varieties three or six weeks after fumigation with 10,000 ppm O₃ under -30.5 cm Hg vacuum at 13 ± 3°C for 6 h.

Week	Coffee variety	Bean	Estimate	Lower	Upper
3	Kenyan	1	0.425	0.205	0.680
3	Sumatran	2	0.575	0.321	0.796
3	Ethiopian	3	0.326	0.140	0.590
6	Kenyan	1	0.525	0.280	0.759
6	Sumatran	2	0.376	0.172	0.636
6	Ethiopian	3	0.326	0.140	0.590

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Week	1	30.4	0.13	0.7227
Bean	2	30.5	1.18	0.3221
Week x bean	2	30.5	0.91	0.4140



Table 2. SAS PROC GLM for control versus O₃ fumigation (same parameters as Table 1) versus fumigation with 48 mg/l MB for 8 h cupping test results with three coffee varieties three or six weeks after treatment.

Week	Comparison	Treatment	Estimate	Lower	Upper
3	Control vs. O ₃	1	0.475	0.201	0.765
3	Control vs. MB	2	0.427	0.172	0.728
3	O ₃ vs. MB	3	0.237	0.075	0.543
6	Control vs. O ₃	1	0.378	0.144	0.687
6	Control vs. MB	2	0.378	0.144	0.687
6	O ₃ vs. MB	3	0.379	0.145	0.688

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Week	1	6.8	0.00	0.9602
Bean	2	12.3	0.46	0.6433
Week x bean	2	12.3	0.47	0.6365



Insect Mortality Tests

Table 3. Response of coffee berry borer life stages^a to fumigation with 10,000 ppm O₃ under -30.5 cm Hg vacuum at 13 ± 3°C for 6 h (totals of 3 replications).

	Eggs		First instar		Second instar		Pupae		Adults	
	C ^b	T ^c	C	T	C	T	C	T	C	T
No. live	217	0	30	0	34	0	37	0	566	0
No. dead	4	1,009	0	116	0	208	0	232	348	3,085
Percent mortality	2	100	0	100	0	100	0	100	38	100

^a No prepupae were treated in the preliminary tests.
^b Control.
^c Treated.

DISCUSSION

➤ Results of the preliminary cupping tests with green coffee grown in Hawaii showed that fumigation with 10,000 ppm O₃ under -30.5 cm Hg vacuum at 13 ± 3°C for 6 h did not reduce coffee quality and were the basis for proceeding with our O₃ research program.

➤ Results (Table 1) of cupping tests with green coffee representing a range of coffee varieties show no significant difference between fumigated coffee and the controls, i.e., coffee flavor and aroma was not adversely affected by O₃ fumigation whether stored for 3 or 6 weeks after fumigation.

➤ Results (Table 2) of cupping tests comparing the quality of green coffee fumigated with O₃ or MB show no significant difference between either O₃ or MB and the controls, and no significant difference between O₃- and MB-fumigated coffee.

➤ Results (Table 3) of preliminary (3 replications) mortality tests with coffee berry borer life stages indicate that O₃ fumigation will control this quarantine pest.

ACKNOWLEDGEMENTS

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INTRODUCTION

Imported green coffee is the foundation for the roasting, blending, and brewing sectors of the Hawaii coffee industry. During 2000-2002, \$116.7 million of green coffee imported each year provided 500 jobs and resulted in value-addition of \$6.6 million to the industry. The Hawaii coffee industry also includes local production on the islands of Hawaii, Kauai, Molokai, Maui, and Oahu (see map above).

Imported green coffee must be fumigated with 48 mg/l methyl bromide (MB) for 8 h to protect Hawaii's coffee production against the coffee berry borer, *Hypothenemus hampei* (Ferrari), and coffee leaf rust, *Hemileia vastatrix* Berkeley & Broom, two of the most destructive pests of coffee not found in the state.

Reduction in green coffee imports translates into economic and job losses to the Hawaii coffee industry, including a unilateral destabilizing effect on the price of green Kona coffee. Nearly half (>500,000 kg) of the annual Kona coffee crop is purchased by roasters for blending. Reductions in green Kona coffee purchases by roasters/blenders directly impact the supply and demand equilibrium for the growers.

Pressure to eliminate MB uses under the Montreal Protocol puts continued green coffee importation into Hawaii at risk and an alternative quarantine treatment is needed. Our goal is to develop O₃ fumigation as an alternative to MB for green coffee under a Cooperative Research and Development Agreement (CRADA) between USDA and Cosmed Group, Inc., using PureOx® Sterilization and Fumigation Services technology and chambers.

We report here results of studies to determine the effects of O₃ and MB fumigation on coffee cupping quality, and preliminary results of mortality tests with coffee berry borer.

^{*}This poster reports the results of research only. Mention of a proprietary product does not constitute an endorsement of a recommendation for its use by USDA.

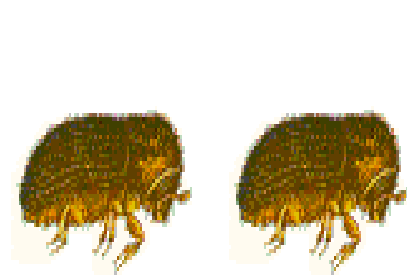


Fig. 1



Fig. 2

METHODS

Treatment Parameters

➤ O₃ fumigation was with 10,000 ppm O₃ under -30.5 cm Hg vacuum at 13 ± 3°C for 6 h in a PureOx® commercial chamber (Fig. 1) for cupping quality tests or in an experimental chamber for coffee bean borer mortality tests. Preliminary data indicated these treatment parameters were more than adequate to provide quarantine security against insect and plant pathogen pests.

➤ MB fumigation was with 48 mg/l methyl bromide (MB) for 8 h at ambient temperature and RH and NAP in a Cosmed commercial MB chamber (Fig. 2) for cupping quality tests.

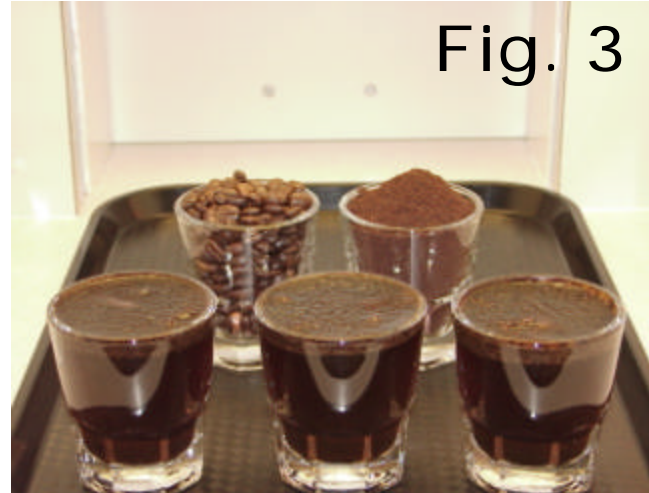


Fig. 3

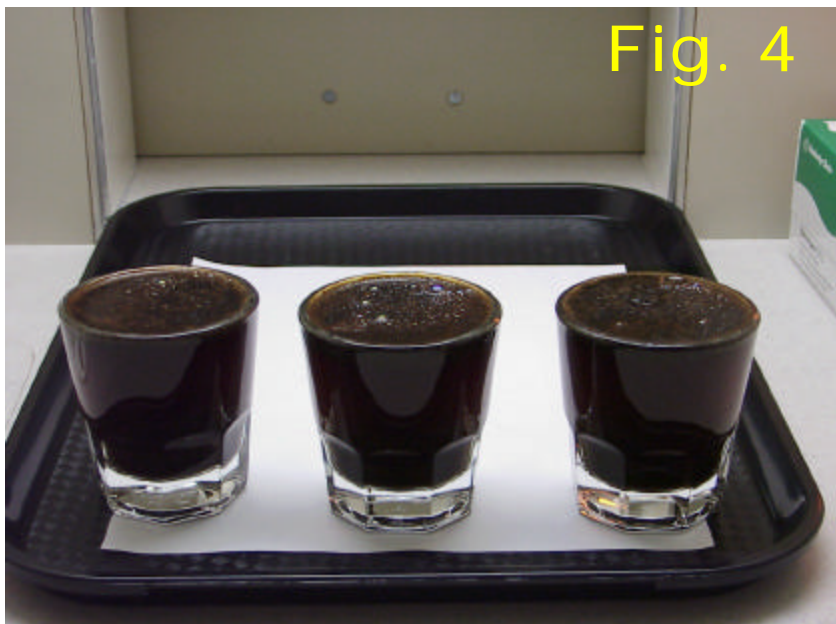


Fig. 4



Fig. 5

Cupping Tests

➤ Preliminary tests with Hawaii-grown coffee to determine quality of O₃-fumigated green beans included 'Yellow Caturra' and 'Red Catuai' from Maui and Molokai, respectively.

➤ Green coffee representing a range of coffee varieties included 'Kenyan' (washed), 'Ethiopian' (unwashed, natural processed) and 'Sumatran' (semi-washed) for O₃ versus control cupping tests, and 'Mexican Organic Chiapas' for MB versus O₃ versus control cupping tests.

➤ Green coffee was fumigated and stored three or six weeks using standard industry methods before cupping tests to determine the effects of storage on fumigated coffee quality.

➤ Fumigated coffee was roasted and ground using commercial conditions, mixed with boiling water (Figs. 3, 4), and served to trained coffee tasters in controlled sensory evaluation laboratories (Fig. 5) at University of Hawaii and at ARS-WRRC using a triangle test to determine significant differences in coffee qualities.

➤ Triangle tests were replicated 3 times and results were analyzed using SAS PROC GLM.



Fig. 6



Coffee berry borer life stages

Insect Mortality Tests

➤ Coffee berry borer eggs, larvae, pupae, and adults (Fig. 6, left to right) were treated in a 20.2-liter experimental O₃ fumigation chamber (Figs. 7-10) and held 3 days before observing larval, pupal or adult mortality, and 5 days before observing egg mortality. Mortality tests were done at ARS-SVASC.



Fig. 9

